Technical Memorandum

To:	Javier Toro Rosemont Copper Company Tucson, Arizona	**Project No:** 1720214024	
By:	Ray Markley, PE	**Reviewed by:** Peter H. Yuan, PE, PhD	
Tel:	(602) 733-6000	**CC:** File	
Date:	November 29, 2021		
Re:	**Piping Sizing Analysis Memorandum** **Heap Leach Facility** **Rosemont Copper World Project**		

1.0 Introduction

Wood Environment and Infrastructure Solutions, Inc. (Wood) has prepared this technical memorandum for Rosemont Copper Company (Rosemont) to present the gravity flow pipe size calculations of the Heap Leach Pad (HLP) at the Rosemont Copper World Project (Project). The fluid management system (FMS) handles the drain-down fluids from the proposed HLP, which is to be drained by gravity via a piping system.

2.0 General

The leach pad drain design includes a three (3)-foot loose lift thickness of crushed minus 1.5-inch clean ore supplemented by drainpipes above the pad liner for gravity drainage to the collection ditch and ponds.

The leach pad is divided into several cells which will be constructed on placed and compacted (engineer-controlled) waste rock overlain with a protective layer. The waste rock will be placed to create a drainage pattern to the centerline of the pad and then toward the west side at an overall design grade of 3 percent (%) or steeper, from the west side of the pad the solution will be conveyed to the process pond via piping. Primary collector pipes convey flow to headers at the downgradient edge and allow for operational monitoring of flows from each cell area. Table 2-1 presents the assumption and design inputs for the gravity flow pipe size calculations.

Table 2-1: Assumptions and Design Inputs

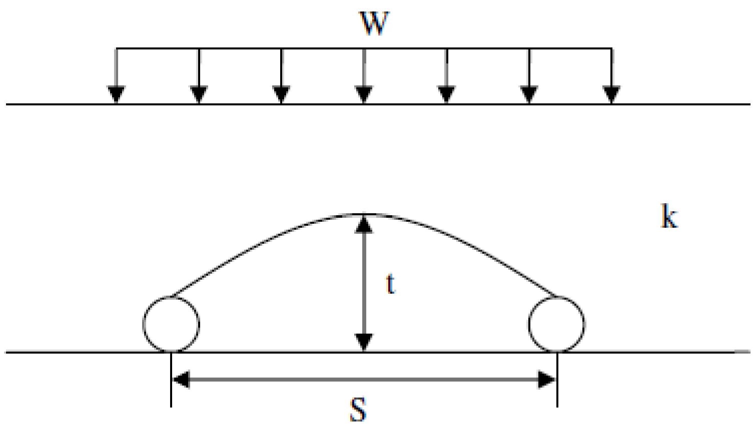
Parameter	Design Input
Maximum operations flow rate (Q)	3,000 gpm
Average unit solution application rate (W)	0.004 gpm/sf
Permeability of overliner material (k)	0.1 cm/sec or higher (confirmed from lab testing of overliner materials as documented in Wood, 2021)
Free draining overliner thickness (t)	3.0 feet (ft)
ADS N-12 Corrugated high-density polyethylene (HDPE) collection pipe (n)	0.012 (Manning's Coefficient)
Minimum HLP slope grade (Qs)	0.03

Notes: ADS = Advanced Drainage Systems, cm/sec = centimeter per second, gpm = gallons per minute, gpm/sf = gallons per minute per square foot, HDPE = high density polyethylene

3.0 Calculations

3.1 Lateral Collection Pipe Spacing

The diagram below shows the relationship between t (overliner thickness) and spacing of lateral collection pipes (i.e., planned 4-inch diameter corrugated perforated polyethylene pipes), S.



The simplified relationship between t and S can be expressed as follows in Equations (Eq.'s) 1 and 2 (if it is assumed that complete drawdown takes places at the subsurface drain – WcWhorter and Sunada, 1977):

$$t^2 = \frac{WS^2}{4k} \qquad \text{Eq. 1}$$

$$\text{Therefore, } S = \left(\frac{4k*t^2}{W}\right)^{\frac{1}{2}} \qquad \text{Eq. 2}$$

From the above equation, S is calculated as 36.6 ft if W = 0.004 gpm/sf (0.00053 cubic feet per minute per square foot [ft^3/min/sf]). For design purposes, 30-ft or nine (9) meters for lateral collection pipe spacing is used.

3.2 Lateral Collection Pipe Size and Lengths

Given the assumptions from Section 2.0, the maximum length of pipe can be calculated for different pipe diameters and slope percentages. The attached Flow Calculation Sheets (Attachments A1 through A5) present the calculations for maximum pipe flow, Q_p, shown in Eq. 3. The maximum pipe flow is then used to find the maximum length of the pipe as shown in Eq. 4.

$$Q_P = \frac{1.49}{n} A R^{\frac{2}{3}} Q_S^{\frac{1}{2}} \qquad \text{Eq. 3}$$

$$L_{MAX} = \frac{Q_P}{S * W} \qquad \text{Eq. 4}$$

However, if collapse or severe deformation of pipe happens, the section area of pipe could be reduced as much as half. Therefore, the maximum allowable length would only be half of that calculated in Eq. 4. The Table 2 summarizes the relationship of pipe slope, calculated maximum lengths and maximum required lengths of collapsed/deformed pipe at a selected pipe diameter of four (4) inches. It should be noted that the assumptions of pipe collapsing or severe deformation is very conservative. In real situations, significant portion of solution flows outside of primary collection pipes instead of inside. So even if the pipe collapses or severely deforms at some locations, the actual flow rate of solution under gravity would not be reduced by 50%.

Table 2 - Pipe Flow and Lengths

Minimum Slope, Q_s (%)[1]	Maximum Flow, Q_p (gpm)[1]	Maximum Length, L_{MAX} (ft)[2]	Maximum Length – Collapsed/Deformed Pipe, L_C (ft)[2]	Maximum Allowable Length, L_A (ft)[2]
1	93	773	386	385
2	131	1093	546	545
3	161	1339	669	665
4	186	1546	773	770
5	207	1728	864	860

Notes:
1. See Attachments A1 through A5 Calculation of Qp, based on pipe slope Qs.
2. Maximum lateral collection pipe lengths and allowable lengths are based on Eq.3 and safety margin discussed above.

The above pipe design slopes/grades and allowable lengths are used for development of pipe layouts for the Lateral Collection System.

3.3 Primary Collection Pipe Selection

Header pipe sizing for the Primary Collection System can be determined from the maximum operational flow rate using the Chezy-Manning Equation (see Attachment A6). The full pipe flow under gravity was calculated for varying pipe diameter sizes with a slope of 3.0% and a Manning's Coefficient of 0.012. The attached Flow Calculation Sheet (Attachment A6) can be used as reference for selecting pipe diameter sizes. The following pipe(s) were assumed:

- Around perimeters of HLP with overburden less than 250-ft, an 18-inch diameter ADS N-12 Corrugated HDPE collection pipe is proposed;

- Around the main solution collection corridors and under overburden depths greater than 250-ft, a DR11 20-inch diameter (16.2-inch inside diameter) HDPE collection pipe is proposed.

The calculated pipe flow under gravity for the above two pipes are approximately 8,870 gpm and 6,697 gpm (Attachment A6), respectively. Therefore, the proposed pipes meet the maximum design flow rate of 3,000 gpm, even with a reduction factor of 50% to account for pipe collapsing and deformation.

4.0 Results

The findings of this calculation were used to evaluate the size and spacing of the piping system. All pipes evaluated herein are dual wall, smooth interior corrugated polyethene pipes.

5.0 References

McWhorter, D. B. and D. K. Sunada, 1977. *Groundwater Hydrology and Hydraulics*, Water Resources Publications, Fort Collins.

Wood, 2021. *Civil and Geotechnical Design Criteria, Rosemont Copper World Project, Pima County, Arizona,* prepared for Rosemont Copper Company, by Wood Environment & Infrastructure Solutions, Inc, November 11, 2021.

Attachment:

Attachment A: Flow Calculation Sheets

ACRONYMS AND ABBREVIATIONS

%	percent
ADS	Advanced Drainage Systems
APP	Aquifer Protection Permit
cm/sec	Centimeters per Second
Eq.	Equation
FMS	Fluid Management System
ft	Feet
ft^3/min/sf	Cubic Feet per Minute per Square Foot
gpm	Gallons per Minute
gpm/sf	Gallons per Minute per Square Foot
HDPE	High-Density Polyethylene
HLF	Heap Leach Facility
HLP	Heap Leach Pad
Project	Rosemont Copper World Project
Rosemont	Rosemont Copper Company
Wood	Wood Environment & Infrastructure Solutions, Inc.

Attachment A: Flow Calculation Sheets

Attachment A1

Full Pipe Flow Under Gravity Worksheet

Project: Rosemont Copper World Project
Date: November 16, 2021
By: R. Markley
Project #: 1720214024

$$Q_P = \frac{1.49}{n} A R^{\frac{2}{3}} Q_s^{\frac{1}{2}}$$

Q_P = gpm
n = Mannings Coeff.
A = Flow Area
R = Hyd. Radius
Q_S = Pipe Slope

Pipe Slope (ft/ft): 0.01 ft/ft
Mannings Coeff., n: 0.012

Circular Pipe Flow

Inside Diameter (inches)	A (ft^2)	R (ft)	Q (gpm)	Q (cfs)	Q(l/s)
4.00	0.09	0.08	93	0.2	5.9
6.00	0.20	0.13	274	0.6	17.3
8.00	0.35	0.17	589	1.3	37.2
10.00	0.55	0.21	1,068	2.4	67.4
12.00	0.79	0.25	1,737	3.9	109.6
14.00	1.07	0.29	2,620	5.8	165.3
16.00	1.40	0.33	3,741	8.3	236.0
18.00	1.77	0.38	5,121	11.4	323.0
20.00	2.18	0.42	6,782	15.1	427.8
22.00	2.64	0.46	8,745	19.5	551.7
24.00	3.14	0.50	11,029	24.6	695.7

Attachment A2

Full Pipe Flow Under Gravity Worksheet

Project: Rosemont Copper World Project
Date: November 16, 2021
By: R. Markley
Project #: 1720214024

$$Q_P = \frac{1.49}{n} A R^{\frac{2}{3}} Q_s^{\frac{1}{2}}$$

Q_P = gpm
n = Mannings Coeff.
A = Flow Area
R = Hyd. Radius
Q_S = Pipe Slope

Pipe Slope (ft/ft): 0.02 ft/ft
Mannings Coeff., n: 0.012

Circular Pipe Flow

Inside Diameter (inches)	A (ft^2)	R (ft)	Q (gpm)	Q (cfs)	Q(l/s)
4.00	0.09	0.08	131	0.3	8.3
6.00	0.20	0.13	387	0.9	24.4
8.00	0.35	0.17	833	1.9	52.6
10.00	0.55	0.21	1,511	3.4	95.3
12.00	0.79	0.25	2,456	5.5	155.0
14.00	1.07	0.29	3,705	8.3	233.7
16.00	1.40	0.33	5,290	11.8	333.7
18.00	1.77	0.38	7,242	16.1	456.9
20.00	2.18	0.42	9,591	21.4	605.1
22.00	2.64	0.46	12,367	27.6	780.2
24.00	3.14	0.50	15,597	34.8	983.9

Attachment A3

Full Pipe Flow Under Gravity Worksheet

Project: Rosemont Copper World Project
Date: November 16, 2021
By: R. Markley
Project #: 1720214024

$$Q_P = \frac{1.49}{n} A R^{\frac{2}{3}} Q_S^{\frac{1}{2}}$$

Q_P = gpm
n = Mannings Coeff.
A = Flow Area
R = Hyd. Radius
Q_S = Pipe Slope

Pipe Slope (ft/ft): 0.03 ft/ft
Mannings Coeff., n: 0.012

Circular Pipe Flow

Inside Diameter (inches)	A (ft^2)	R (ft)	Q (gpm)	Q (cfs)	Q(l/s)
4.00	0.09	0.08	161	0.4	10.1
6.00	0.20	0.13	474	1.1	29.9
8.00	0.35	0.17	1,020	2.3	64.4
10.00	0.55	0.21	1,850	4.1	116.7
12.00	0.79	0.25	3,008	6.7	189.8
14.00	1.07	0.29	4,538	10.1	286.3
16.00	1.40	0.33	6,479	14.4	408.7
18.00	1.77	0.38	8,870	19.8	559.5
20.00	2.18	0.42	11,747	26.2	741.0
22.00	2.64	0.46	15,146	33.7	955.5
24.00	3.14	0.50	19,102	42.6	1205.0

Attachment A4

Full Pipe Flow Under Gravity Worksheet

Project: Rosemont Copper World Project
Date: November 16, 2021
By: R. Markley
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$$Q_P = \frac{1.49}{n} A R^{\frac{2}{3}} Q_s^{\frac{1}{2}}$$

Q_P = gpm
n = Mannings Coeff.
A = Flow Area
R = Hyd. Radius
Q_S = Pipe Slope

Pipe Slope (ft/ft): 0.04 ft/ft
Mannings Coeff., n: 0.012

Circular Pipe Flow

Inside Diameter (inches)	A (ft^2)	R (ft)	Q (gpm)	Q (cfs)	Q(l/s)
4.00	0.09	0.08	186	0.4	11.7
6.00	0.20	0.13	547	1.2	34.5
8.00	0.35	0.17	1,178	2.6	74.3
10.00	0.55	0.21	2,136	4.8	134.8
12.00	0.79	0.25	3,474	7.7	219.1
14.00	1.07	0.29	5,240	11.7	330.6
16.00	1.40	0.33	7,481	16.7	471.9
18.00	1.77	0.38	10,242	22.8	646.1
20.00	2.18	0.42	13,564	30.2	855.7
22.00	2.64	0.46	17,490	39.0	1103.3
24.00	3.14	0.50	22,057	49.1	1391.4

Attachment A5

Full Pipe Flow Under Gravity Worksheet

Project: Rosemont Copper World Project
Date: November 16, 2021
By: R. Markley
Project #: 1720214024

$$Q_P = \frac{1.49}{n} A R^{\frac{2}{3}} Q_S^{\frac{1}{2}}$$

Q_P = gpm
n = Mannings Coeff.
A = Flow Area
R = Hyd. Radius
Q_S = Pipe Slope

Pipe Slope (ft/ft): 0.05 ft/ft
Mannings Coeff., n: 0.012

Circular Pipe Flow

Inside Diameter (inches)	A (ft^2)	R (ft)	Q (gpm)	Q (cfs)	Q(l/s)
4.00	0.09	0.08	207	0.5	13.1
6.00	0.20	0.13	612	1.4	38.6
8.00	0.35	0.17	1,317	2.9	83.1
10.00	0.55	0.21	2,388	5.3	150.7
12.00	0.79	0.25	3,884	8.7	245.0
14.00	1.07	0.29	5,858	13.1	369.6
16.00	1.40	0.33	8,364	18.6	527.6
18.00	1.77	0.38	11,451	25.5	722.4
20.00	2.18	0.42	15,165	33.8	956.7
22.00	2.64	0.46	19,554	43.6	1233.5
24.00	3.14	0.50	24,661	54.9	1555.7

Attachment A6

Full Pipe Flow Under Gravity Worksheet

Project: Rosemont Copper World Project
Date: November 16, 2021
By: R. Markley
Project #: 1720214024

$$Q_P = \frac{1.49}{n} A R^{\frac{2}{3}} Q_s^{\frac{1}{2}}$$

Q_P = gpm
n = Mannings Coeff.
A = Flow Area
R = Hyd. Radius
Q_S = Pipe Slope

Pipe Slope (ft/ft): 0.03 ft/ft
Mannings Coeff., n: 0.012

Circular Pipe Flow

Inside Diameter (inches)	A (ft^2)	R (ft)	Q (gpm)	Q (cfs)	Q(l/s)
16.20	1.43	0.34	6,697	14.9	422.5
18.00	1.77	0.38	8,870	19.8	559.5